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A CONTRIBUTION TO THE SOFT ANATOMY OF CRETACEOUS FISHES AND A NEW PRIMITIVE HERRING-LIKE FISH FROM THE TEXAS CRETACEOUS.

BY ROY L. MOODIE.

(Contribution from the Zoölogical Laboratory, No. 191.)

Plates LX to LXII.

THERE have been, during the past few years, several additions to our knowledge of the soft parts of extinct animals. This knowledge has to do, in large part, with the firmer tissues, such as the cartilaginous portions of the skeleton, the skin, the muscles, but in some cases the kidneys, oviducts, nervous tissues, blood vessels and alimentary canal are clearly preserved. Dean (*1*) has been especially fortunate in the discovery of some of these structures in the sharks of the Cleveland shales of Ohio. He has described very fully the preservation of the kidneys, muscles, skin, the cartilaginous elements of the fins and arches and portions of undigested food. So perfectly are the remains preserved that the tissues, in some cases, admit of histological differentiations into the component elements. Eastman (*2*) has described the preservation of the outline of some acanthodians from Mazon Creek. Woodward (*3*) has contributed to our knowledge of the soft anatomy of fossil fishes in many ways and has added interesting information on the anatomy of the lateral line system of Cretaceous selachians. Jaekel (*4*), Dean (*1*, p. 267) and Gill (*5*) have discussed the anatomy and the significance of Jurassic and Cretaceous chimæroid egg cases. Otto Reis (*6*) has written much on the soft anatomy of various fossil fishes, more

especially the Cœlacanthidæ, in which he has described the form of the muscle fibers, the swim bladder and other structures. Eastman and Parker (*21*) have described the preservation of the brain, the internal ear and arterial vessels in *Rhadinichthys deani* Eastman from the base of the Waverly shales, Kentucky. Dean (*20*) has mentioned the preservation of the lateral line sensory canals of the head, the auditory organ and the rim of the nasal capsule in *Acanthodes bronni* from the Permian of Lebach, preserved in the Berlin Museum. Fritsch (*7*) has described very accurately the outlines of the body and fin membranes of *Pleuracanthus*. Traquair (*8*), Dean (*1*) and Sollas (*9*) have added to our knowledge of the anatomy of *Paleospondylus*. Patten (*10*), Eastman, Traquair and others have written on various structures of the Ostracophores. Other authors have contributed from time to time on the subject, until we have, in some instances, *e. g., Bothriolepis, Paleospondylus, Cladoselache,* a fairly definite idea as to the outward form and internal structure of the creature. Among higher animals something has been done on the soft anatomy of the extinct Amphibia, Ichthyosauria, and Dinosauria.

It is with some degree of pleasure that the writer is able to add to the knowledge of the soft anatomy of extinct forms by the discussion of the alimentary canal of two Cretaceous fishes. One is a species of *Empo,* probably *E. nepaholica* Cope, from the Niobrara Cretaceous of western Kansas, and the other is a new species of clupeoid fish from the Cretaceous of Texas.

The specimen which probably belongs to *Empo nepaholica* Cope consists of the cast of a large stomach which, in all probability, represents a fish of some ten or twelve feet in length. It is No. 347 of the University of Kansas Paleontological Collection. The remains were discovered in 1897 by Mr. H. T. Martin in the Niobrara chalk four miles northwest of Elkader, Kan. The specimen has recently been presented to the Museum of the University by Mr. Martin.

The specimen consists of a cast of the larger portion of the alimentary canal of a large species of fish. Attached to the matrix of the cast on one side is the major portion of the right pectoral fin, which is described and figured below. So far as the writer is aware, the present specimen is the most perfect example of the pectoral limb of an *Empo* which has been de-

scribed. Cope (*18a*) figured an incomplete one and Hay mentioned another. Hay (*11*) has figured a portion of the caudal fin of an *Empo* showing the extreme character of segmentation of the rays. The same character is shown in the pectoral fin.

The stomach is rounded, somewhat laterally compressed, and elongate in a slightly U-shaped curve. There are eight muscular constrictions on the ventral surface and four on the dorsal. The constrictions, on the ventral surface, occur in groups. Anteriorly there are two close together. This group is separated by a space of an inch and a quarter from the next group, in which there are three, which occur a little over one-half inch apart. The last group, also of three, is separated from the second group by one inch. The surface of the stomach cast is covered with a dark, apparently carbonaceous, material which may be carbonized muscle, together with a few large scales of the typical *Empo* form. Running the entire length of the specimen are longitudinal ridges and grooves showing the cast of the muscular walls of the stomach.

The interior of the stomach, in cross section, shows no food material, but only chalk. It is possible that the fish, like some of its modern relatives, may have been a bottom feeder and its stomach may have been partly filled with Niobrara mud at the time of its death. There must, however, have been some sediment enter the stomach after death, for the full form of the organ is preserved as though the entire stomach cavity had been packed with mud. Furthermore, the form of the stomach is that of a carnivorous fish, and recalls very strongly the stomach of a mountain trout or of the sunfishes of our inland streams, all carnivorous in habit.

The portion of the alimentary canal preserved is in two lobes. The first lobe is undoubtedly the stomach proper, and the constriction between the lobes is the pyloric region. The other lobe is unlike anything among modern fishes with which I am at present acquainted. It is undoubtedly an enlargement of the intestine and possibly served as a secondary stomach. It lacks the muscular constriction and the longitudinal plicæ. The plicæ are, however, continued well across the pyloric region to the beginning of this second enlargement.

The pectoral fin, as preserved, is well characterized in the photograph (plate LXII, figure 2). It is somewhat turned in-

ward and bent, during interment, back against the stomach. There are eleven rays preserved. The anterior rays are cross segmented with long divisions, which measure 7 mm. in length in the second ray. The square notches mentioned by Hay (*11*, p. 87) as occurring on the specimen of *Empo nepaholica* Cope in the United States National Museum, are entirely lacking from that portion of the anterior ray which is preserved in the present specimen. The teeth on the edge are also absent, nor do I find that they are evident in Cope's figure referred to by Hay. The figure is very indistinct, and if the notches were present they could not, in the nature of the case, be normal, but would represent places where the segments had dropped out. The first ray is not a spine. In other respects the present specimen agrees well with that figured by Cope on plate LII, figure 1 (Cretaceous Vertebrata). The fifth and succeeding rays are segmented like the anterior ones, but the segments are smaller and measure, on the average, only about 2 mm. The seventh ray is especially broad, equaling in its proportions two and one-half of the other rays. All of the rays are split distally. The seventh divides into four secondary rays and the divisions ascend more and more to the base of the fin posteriorly. The fin supports are obscured by scales and matrix so that their nature cannot be determined. On the opposite side of the specimen, below the pectoral fin, there are large scales and fragments of ribs.

The second intestinal enlargement is interesting, entomologically, as showing the borings of some fossorial hymenopteron; possibly some one of the smaller species of the Andrenidæ. There are fragments of pupa cases in the burrows, so there is no doubt as to the recent origin of the holes.

The present specimen is so far the only remains known of the soft anatomy of the Kansas Cretaceous fishes, and, so far as I can learn, the first indication of the alimentary canal of Cretaceous bony fishes of any region. Whether the stomach and intestines in their various forms will ever be of any help in determining the relationship of the various osseous fishes remains to be determined. It is to be feared, however, that the fishes have been so diversified according to food habits that these structures will not be of any great phylogenetic value. The remains are interesting, however, as indicating, in a measure, the habits of life of at least one of the Cretaceous fishes.

Measurements of the specimen of *Empo nepaholica* Cope:

Entire length of the alimentary canal as preserved	53.2	cm.
Greatest diameter at anterior end	10	
Least diameter, across pyloric region	3	
Greatest diameter of posterior enlargement	7.4	
Length of pectoral fin as preserved	9	
Greatest width of fin	3.7	
Length of first ray	8	
Width of first ray	2	mm.
Diameter of large scale	15	

Thrissopater intestinalis new species.

A species of clupeoid fish is represented in the University Museum by the remains here described as a new species. The form is located in *Thrissopater* of Günther, described from the Gault of Folkstone in 1872 (*12*). My thanks are due Dr. A. Smith Woodward for the suggestion of a comparison of the present form with that of *Thrissopater*. It was thought for a time that the present form represented a genus distinct from *Thrissopater*. The distinguishing character was thought to be found in the position of the pelvic fins, which has served as a generic character in other fishes. In *Thrissopater salmoneus* the pelvic fin is opposite the dorsal and in the present form it is distinctly posterior to it. There is, however, a great range of variation in the position of the pelvic fin, especially among the lower osseus fishes. My thanks are due Prof. E. C. Starks for aid in reference to the characters of the modern bony fishes. During the summer of 1909 the writer spent some weeks studying with him the fishes of Puget Sound. He first called the writer's attention to the wide variation of the location of the pelvic fin in the clupeoid fishes. This variation is easily understood when it is remembered that the pelvic fin lies free from any firm attachment and hence its variation in location would not mean as much as though it were attached to the scapular arch. Further aid was rendered the writer in determining the characters of the clupeoid fishes by Dr. W. G. Ridewood, of London. An examination of the essays of this gentleman has been of great service.

The absence of material for direct comparison with the species of *Thrissopater* makes it best to locate the present form temporarily in that genus. The systematic position of *Thrissopater* has been the subject of a wide variance of opinion. Dr. Günther regarded *Thrissopater* as closely allied to the modern Clupeidæ and located it (*13*) in that family, in which he also included such forms as *Spaniodon, Albula, Elops*

and *Engraulis*, all of which have been regarded by different authors as types of distinct families. Boulenger (*14*) regards *Thrissopater* as a member of the subfamily Thrissopatrinæ, which is one of his four subfamilies of the Clupeidæ. Dr. Jordan (*15*) located the form in the family Spaniodontidæ, which is closely related to the Elopidæ, between which and the Clupeidæ Boulenger regards *Thrissopater* as being intermediate (l. c., p. 564). Professor Starks writes me that Doctor Jordan now regards the family Spaniodontidæ as untenable. Dr. A. Smith Woodward (*16*) regards *Thrissopater* as a member of the Elopidæ, which differ from the Clupeidæ in the possession of a single supramaxillary, the degree of union of the parietals and the gape of the mouth and the presence of a gular plate. The present form presents the characters of the Elopidæ in so far as they are preserved. In recent forms, the presence of a gular plate in the Elopidæ serves as a convenient landmark for the distinction of the families of the Elopidæ and Clupeidæ. As a matter of fact, the families are so closely allied that the characters used for their separation must in time be broken down by the discovery of new material.

Herrings and herring-like fishes are not at all rare in the Cretaceous deposits of the world. Davis (*17*) has described many forms of clupeoid fishes from Mount Lebanon. Before him Agassiz advanced the knowledge of these forms, and latterly Woodward has described several interesting clupeoids. Cope described several clupeoids from the Eocene of Green River, Wyoming (*18*), and Jordan has cited the interesting relations of these forms to forms now living in the rivers of Australia and Chili. At the present time herrings form an important item in the economic history of the world. Huxley has dwelt (*19*) especially on the anatomy and relations of the herring in this connection. The present form adds yet another mite to our knowledge of these interesting fishes. It is believed to be as early as or perhaps somewhat older than many of the described clupeoids. The specimen comes from the Austin shales or limestone, which is a probable equivalent of the Niobrara Cretaceous. It is from near Baylor, Tex., and is No. 300 of the University of Kansas Museum.

The remains preserved consist of the nearly complete fish, as may be determined from an examination of the plate. The caudal portion is, unfortunately, lacking. The outer surface of the skull was badly broken and Mr. Martin very kindly ex-

tricated the skull for me from the matrix. It was a difficult task and the results were hardly worth the efforts, for the embedded portion was but little better preserved than the outer. Enough of the skull is preserved, however, to show many of the important characters. The head is naked; the body compressed, but whether the ventral edge was drawn out into a keel or not cannot be determined from the specimen. The mandible is fully as long as the skull. The relations of the articulation to the orbit cannot be determined, nor can the position of these openings be definitely located. The parietal bones are, apparently, small. Certainly the supraoccipital projects forward as in *Thrissopater magnus*. Maxilla is slender, with a single supramaxillary. The margin of the jaws is provided with a single row of small, recurved, sharply pointed teeth of uniform size throughout the length of the entire mandible and maxilla. The quadrate is broadly V-shaped, with a prominent articular surface. Nasal, ethmoid and premaxillary bones ornamented with numerous small pits. The same character occurs on the anterior end of the maxilla of the right side. A single, squarish, punctate, thick, pharyngeal bone is present. A very few branchiostegal rays are preserved; not over ten. From the relationships of the form we would judge there were many in the complete fish. The opercular apparatus is smooth. Posterior suborbital plate radiately furrowed; its extent exceeding one-third of the length of the skull; remaining elements indistinct. Greatest depth of the body is slightly greater than the length of the skull from premaxilla to supraoccipital. The length of the body is possibly equal to four times the length of the skull. The fins are relatively small. Dorsal fin median in position. The pectoral fin has sixteen rays, which are cross-segmented but are not divided longitudinally. The rays are supported by five baseosts. The distance between the origins of the pectoral and pelvic fins is equal to nearly four times the length of the pectoral fin. The pelvic fins have nine rays, none of which are cross-segmented. The pelvic bone is large and spatulate.

The body scales are small, cycloid, deeply imbricated and marked with fine concentric lines. There is a large, elongated and elegantly sculptured scale at the base of the pectoral fin, as in *Thrissopater salmoneus;* though in the present instance the scale is less than one-half the length of the pectoral fin rays. The vertebræ are preserved to the number of thirty-

four. There may have been as many as forty-five or fifty in the complete fish. They are fully ossified, slightly constricted and marked with small longitudinal ridges. The length is slightly greater than the depth. The neural spines are long and interlock with the interneurals. Supernumerary ribs present. Six of them occupy the space of a single vertebral centrum.

The specimen as preserved is well characterized by the figures. The fish lacks the posterior end of the body back of the anus. It is chiefly remarkable on account of the extraordinary preservation of the casts of the rectum and intestine, of which there are six coils or loops preserved. The remains are embedded on the right side in a calcareous, arenaceous, shaley limestone, which also contains remains of some species of *Inoceramus*, small fish teeth and the base of a moderately large shark's tooth.

Perhaps the most interesting portion of the entire specimen is the intestinal canal, from the presence of which is derived the specific name. In general features the alimentary canal as preserved recalls that of the common fresh-water buffalo fish, *Ictiobus bubalus* Raf (plate LXII, figure 1). The similarity in form is undoubtedly indicative of similarity of habit, and since we know that the buffalo fishes are bottom feeders we can easily predicate that our ancient Cretaceous fish had similar habits and at the time of its death the alimentary canal was filled with mud mixed with some organic substances; for the fossil shows a different texture for the cast of the alimentary canal from the matrix, indicating different materials. The intestine as preserved consists of six coils or loops of the very small intestine which immediately precedes the rectum, which is likewise preserved. The rectum is elongate but no more so than is the same structure in the buffalo fish. The essential characters are shown in the illustrations.

The distinction of this species from the other three which have been assigned to *Thrissopater* is to be found, first of all, in the posterior location of the pelvic fin. Its base lies at a distance posterior to the back edge of the dorsal fin, which is equal to its own length. So far as I am aware the large axillary scale in other species of *Thrissopater* is larger and unornamented. From *T. salmoneus* Günther the present form is to be distinguished by the relative proportions of the head and

body. The head and opercular apparatus is contained only about twice or at most two and one-half times in the body. From *T. magnus* it is to be differentiated by the relative proportions of the opercular and the skull. The former is contained twice in the latter in the present form. In *T. magnus* it is contained three times. The present species is indeed very closely allied to *Thrissopater magnus* Woodward from the Lower Chalk of Hollingbourn, Kent. It is to be distinguished by the relative dimensions of the vertebræ as well as by the proportions existing between skull and opercular. The vertebræ in *T. magnus* are higher than long while in *T. intestinalis* they are slightly longer than high, and the ends are occupied by distinct rims, such as do not occur, apparently, in the English form. The characters which the two species have in common are striking. They both have the same notch in the anterior end of the mandible; the same finely punctate ethmoid and nasals; the same form and dimensions of mandible and maxilla; the same divided posterior suborbital; and the same relative shape of skull. Many of these are generic characters.

The present species can be distinguished from *Thrissopater* (?) *megalops* Woodward by the proportions of the head. In *T.* (?) *megalops* the height of skull from cotylus to supraoccipital is equal to the length of the mandible, while in *T. istestinalis* the mandible exceeds the height of the skull from cotylus to supraoccipital by 15 millimeters. It may be further distinguished by the relative proportions of the pectoral arch and skull as well as by the absence of the radiately furrowed suborbital and the notch in the anterior end of the mandible in *T.* (?) *megalops*.

Measurements of *Thrissopater intestinalis* Moodie:

Length of specimen	29	cm.
Greatest depth	9	
Length of skull (with opercular apparatus)	9.7	
Depth of skull at quadrate	4.8	
Length of mandible	6	
Depth of mandible at cotylus	1	
Diameter of pharyngeal plate	9	mm.
Length of tooth	2.5	
Width of opercular apparatus	3	cm.
Length of clavicle	2.5	
Length of pectoral fin	2.5	
Width of pecoral fin	1.2	
Length of pelvic fin	2.4	
Width of pelvic fin	1.2	
Length of actinost	3	mm.
Length of dorsal fin as preserved	2.1	cm.

Width of dorsal fin as preserved	1.8	
Length of caudal hæmapophyses	9	mm.
Length of vertebræ	6	
Depth of vertebræ	5	
Width of small intestine	3	
Length of rectum	12	cm.
Width of rectum	1.3	
Length of interneural	1	

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